

## Noise, Worker Perception, and Worker Concentration in Timber Harvesting Activity

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### Abstract

*Timber harvesting activities are unquestionably related with high risk of work accidents and health disorders. Such activities were not only burdened the workers with heavy physical workloads due to uneasy working environment, and massive work materials and tools, but also physiopsychologically burdened workers as they were imposed with both mechanical and acoustic vibrations (noise) produced by the chainsaw. However, it is a common practice that most of the workers still ignored the importance of the use of noise reduction devices such as earmuff or ear plug. This study was aimed to reveal the factual effects of noise on work concentration of the workers to provide a scientific basis in supporting efforts in improving workers' attitude. The results confirmed that chainsaw might produce noise during operation. Noise intensities received by both right and left ears were not significantly different, indicating that left-handed and normal workers received similar degree of noise in both side of ears. Further, results also showed that there was a significant difference on the perception and work concentration of chainsaw operators versus sedentary people to the noise. These findings proved that hearing ability of chainsaw operators had declined due to frequent noise exposure.*

*Keywords: timber harvesting, physio-psychological disorder, noise, chainsaw*

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### Introduction

Logging activities have high risks of occupational safety and health disorders (Nieuwenhuis & Lyons 2002; Sessions 2007) in the form of physical or psychological disorders. In addition due to an uncomfortable work environment (Yovi 2005), there are also due to the heavy workload of the employee (Yovi 2006), mechanical and acoustic (noise) vibrations and exhaust gas emissions produced by work equipments.

As set in the Ministerial Decree No. 48/MENLH/11/1996, noise is defined as unwanted sound from efforts or activities within certain period and level that can cause health disorder in humans and produced uncomfortable environment. Health problems may arise in the form of a chain reaction that starts with a physical disorder of declining ability of hearing high frequencies (> 4KHz) (Boateng & Amedofu 2004) or changes in blood pressure (Melamed *et al.* 2001), which in turn can lead to psychological disorders such as annoyance, anxiety, and stress which in turn decreases work concentration (Kroemer & Grandjean 1997). Reduced work concentration will decrease work productivity and at the same time will increase risk of workplace accidents.

To protect the safety and health of workers, the government has issued various policies related to the threshold value of noise standard (including Minister of Manpower Decree No. Kep-51/MEN/1999 on Threshold Value of Noise Standards at Work Sites). The government has also adopted the logging work standards formulated by the International Labour Organisation (ILO 1998). However, until now the practice of logging without proper protective devices

including ear protectors is still very common and easy to find in Indonesia.

Research on logging workers job competencies in various forest management units (Yovi *et al.* 2011) indicate a low job competence as one of the causes of these false practices. Nevertheless, results of various interviews with logging workers indicate another cause of their reluctance of workers to not using hearing protectors. Some of the interview results indicate that in addition to the inconvenience caused, the reluctance of workers to use protective devices is caused by their perception that they do not experience hearing loss. Workers claim that they can still well perform daily communication (the frequency of daily conversation is within the range of 500–2000 Hz), although in further interviews and observations, almost all chainsaw operators respondents in this study prefer to listen to the radio or watch television with a loud voice. The unconsciousness of the workers with regard to interruption of their hearing is caused because people with noise trauma are more likely to experience noise induced hearing loss, especially at high frequencies (Takahashi *et al.* 1987; Boateng & Amedofu 2004). In such cases, employees will realize that they have experience hearing impaired after medical examinations have been conducted (Salvendy 2006).

Chainsaw is known as a major source of noise in logging activities. The chainsaw that is commonly found in logging activities in Indonesia is a chainsaw with a blade length of 90 cm and weighing about 17–18 kg (dry weight). A widely used typical chainsaw also include chainsaws that are not well maintained and had been modified several times. Lack of

financial capacity is usually the underlying reason for the modifications that are not based on standard. This in turn will cause the chainsaw to produce emission and vibrations that can deliver a devastating effects on workers compared with the chainsaw that is properly maintained.

Noise is the major cause of global work disorders (Koh & Jeyaratnam 1998; Uimonen *et al.* 1998). Based on the idea that working with safety and being healthy are the rights of workers, research on perception and loggers' working concentration ability is necessary. Noise caused by chainsaws are the focus in this research, particularly in exploring the underlying reasons for the workers' statements about their perceptions of chainsaw sounds as opposed to a variety of health research results regarding the effect of noise. In order to provide comprehensive research results, analysis on the estimated decline in work concentration due to noise exposure is also performed. The results were expected to be used as one important information to be given to logging workers, making it easier for them to receive an understanding of the dangers of noise and raises awareness of the risk of noise exposure that will ultimately enhance the work competence of the workers.

## Methods

Sound level meter was used to measure the sound intensity of chainsaw, earmuff, and earplug as ear protectors. As many as 30 respondents were selected comprising of chainsaw operators (representing logging workers) and non-chainsaw operators (representing workers not exposed to chainsaw noise). Data were collected through direct measurement techniques, structured interviews, and field observations. Direct measurement techniques were performed to measure the intensity of chainsaw noise at various points of measurement consisted of source of noise (engine), right and left ears. Measurements on both ears were performed to determine the effect of body posture against noise exposure of the chainsaw. Direct measurements were performed to determine the effect of chainsaw noise exposure on the concentration ability of the respondents. In these measurements, the measured noise intensity was the equivalent intensity which is the average of total and peak intensities.

Interviews were conducted to determine the perceptions of both groups of respondents to the noise emitted by chainsaw under 3 conditions: iddle (trigger was not pulled), half racing (half the trigger was pulled), and racing (full trigger). Perceptions were measured using Likert scale (1–5; a scale of 1 means very noisy, a scale of 5 indicates very quiet). The combination of treatments applied to each chainsaw condition was that respondents were not wearing hearing protection, earmuffs, and earplugs. After being exposed to noise with a combination of these treatments, the concentration of respondents was measured through a simple 25 math problems that must be answered within 10 minutes.

## Results and Discussion

**Chainsaw noise level** In this study, the respondent's body position while holding a chainsaw (Figure 1) was adjusted to the body position of chainsaw operator in logging activity (Figure 2). Based on Wilcoxon test results against chainsaw noise measurement data on various combinations of treatments (Figure 3), it was known that significant difference occurred between sound intensity received by both ears and noise intensity of chainsaw caused by the distance of the chainsaw to the operator's ear, in addition to surrounding materials/environment (including wind) that influence the reduction of sound transmitted to ears (Figure 3). Although the result was insignificant (value of Asymp. Sig. >  $\alpha$ ; 0.05), sound intensity emitted to left ear tent to be greater than the right ear, which is caused by the respondent's position when holding chainsaws. All respondents were right-handed so the chainsaw was positioned on the left side of the body (Figure 1). The insignificant noise intensity transmitted to both ears, indicated that data analysis on the perceptions and decline work ability also applied equally to left-handed workers. In terms of absolute sound intensity, sound intensity transmitted to both ears was expected to be higher, but this study did not measure such sound intensity due to limited facilities and available measuring equipments.

Figure 3 also showed that the intensity of chainsaw sound transmitted to the the ears ranged between 78 (iddle) to 104 dBA (racing). The highest range of sound intensity in this study was slightly lower than the intensity range specified by Kroemer and Grandjean (1997), but this difference was acceptable given various chainsaw performances due to maintenance and use of various spare parts. When the chainsaw was turned on at iddle conditions, the average



Figure 1 Worker's position in handling chainsaw.



Figure 2 General position of a chainsaw operator.

sound intensity transmitted to the ears of the respondents was 80.18 dBA (Figure 3). This value is still under reasonable threshold according to ISO (International Standards Organization), OSHA (Occupational Safety and Health Association), and standards issued by the Indonesian government for the duration of exposure of 8 hours (Table 1). At half-racing condition, the average intensity of sound transmitted to the ear was 93.78 dBA meaning that noise caused by chainsaw would not cause serious disorders if the exposure to chainsaw noise was less than 1 hour (ISO standard), or 4 hours (OSHA standards), and 2 hours (Indonesian standard). If the chainsaw were turned on racing condition, the average sound intensity received by the respondents was 101.93 dBA, meaning that workers could not be exposed for more than 0.25 hours (standard ISO), 1 hour (OSHA standards), and 0.5 hours (Indonesian standard). Sound intensity at 93.78 and 101.93 dBA levels were classified as high-level noise exposure (Hernandez-Gaytan *et al.* 2000; Osibogun *et al.* 2000; Sriwattanatamma & Breyse 2000; Ahmed *et al.* 2001). Thus, the sound generated by a chainsaw during half racing and racing could be classified as noise in terms of occupational health aspects.

On the other hand, in the study of workload, Yovi *et al.* (2005) states that within 1 working day in average, a chainsaw operator operated the chainsaw in a racing state for 3 hours (for the activities of felling, bucking and delimbing). This signified that for every work, a chainsaw operator would be exposed to high level of noise exceeding the time limit recommended by ISO, OSHA, and Indonesian standards. Such duration might cause impact on the hearing ability of the workers (Boateng & Amedofu 2004).

**Respondent's perception on noise** In addition to workloads

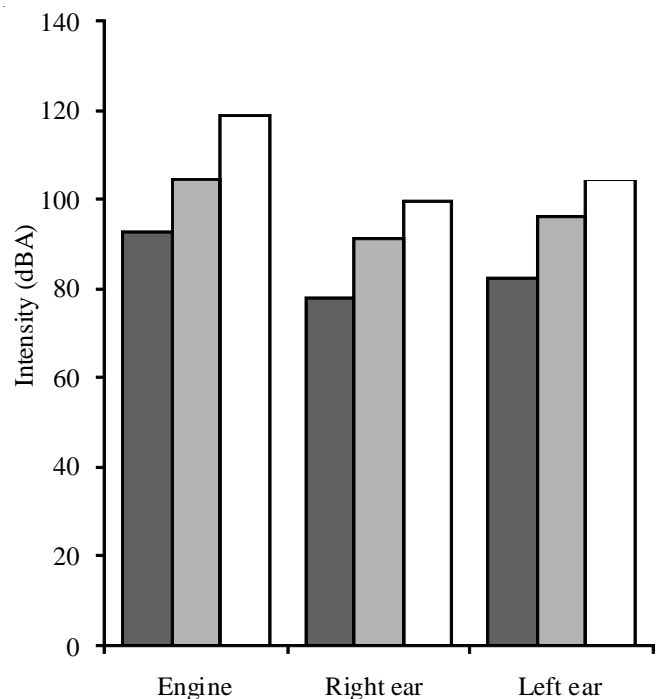


Figure 3 Intensities of noise emitted by chainsaw during idle, half gas, and racing. Idle (■), half gas (▒), racing (□).

Table 1 Several threshold noise standards and recommended duration of continuous work

Intensity (dBA)			Duration of work (hour)
ISO	OSHA	Indonesia	
85	90	85	8
-	92	87,5	6
88	95	90	4
-	97	92,5	3
91	100	95	2
94	105	100	1
97	110	105	0,5
100	115	110	0,25

Source: ISO, OHSA, and Kepmenaker No. 51/1999.

due to large sized chainsaw (Yovi *et al.* 2005), noise is one of the problems caused by the use of chainsaws. Noise of the chainsaw was caused by the movement and friction of the motor fuel components that caused a change in air frequency and pressure, besides to high-speed rotating chain movement rubbing against the blades.

Analysis of perception on chainsaw sound indicated significant differences between chainsaw operators and non chainsaw operators for the 3 applied chainsaw conditions, and both when using or not using ear protectors (Figure 4, Figure 5, and Figure 6). This perceptual difference might occur because perception from the same object/circumstances

could provide different reactions on different respondents. This difference would determine the level of taste toward an object. In this research, it was noted that chainsaw sounds at half racing and racing conditions which were perceived as high-level noise would not be regarded as disturbance by the operators. On the contrary, the non-operator

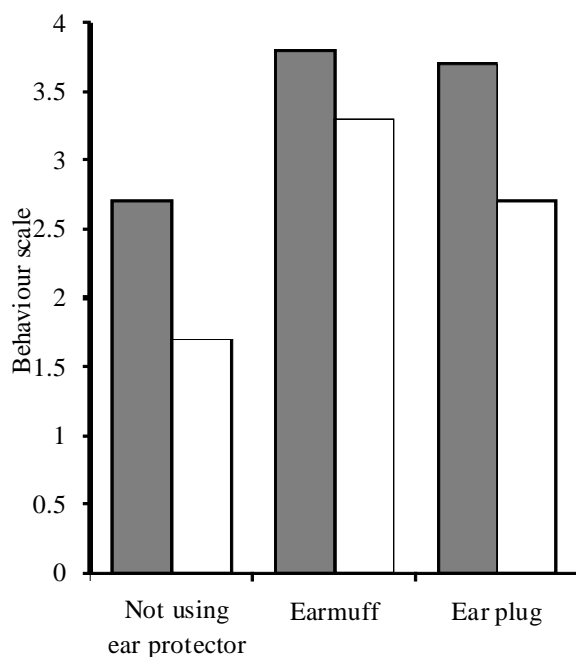


Figure 4 Perception of chainsaw operator versus non operator on receiving noise during iddle condition. Operator (■), non operator (□).

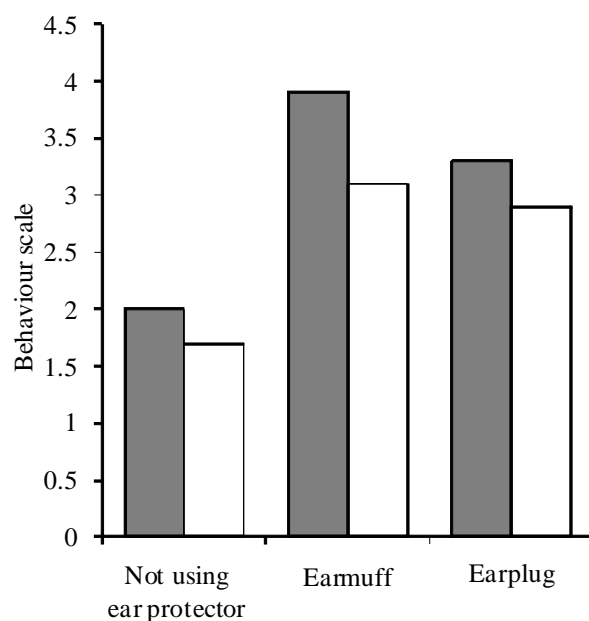


Figure 5 Perception of chainsaw operator versus non operator on receiving noise during half-racing condition. Operator (■), non operator (□).

group perceived the sound generated by the chainsaw under both conditions as disturbing and unwanted (noise).

Analyses of perceptions were conducted based on the assessment results according to the perception of a Likert scale. Perception analysis indicated that at iddle condition, the transformation of the perception of chainsaw operators and non-chainsaw operators before and after wearing ear protection devices ( earmuffs and earplugs) were quiet noisy to not noisy for operators, and very noisy to noisy for non-operators (Figure 4). At half racing conditions, the results were noisy to not noisy for operators after wearing earmuffs and quiet noisy after wearing earplug, while for the non-operators the results were very noisy to quiet noisy after wearing both devices (Figure 5). While at racing condition, the perceptions were similar for both groups, that is very noisy and after wearing earmuffs and earplugs, the results were quiet noisy and noisy respectively.

Data shown in Figures 4, Figure 5, and Figure 6 suggested that both groups of respondents showed a tendency of having similar perceptions, where a received higher sound intensity would be followed by feeling of disturbance. However, there was a clear perceptual difference between chainsaw operators and non-operators visible at half racing condition (Figure 5).

The perceived perceptions by the 2 groups of respondents indicated that operators were actually disturbed by the noise intensity of the chainsaw. This group also realized that in order to reduce the noise, they should use ear protectors. However, too much exposure to chainsaw noise have made them ignored the disturbances that they actually felt, and even regard it as a common thing, which is contrary to medical recommendations from various studies about the effects of high intensity noise exposure.

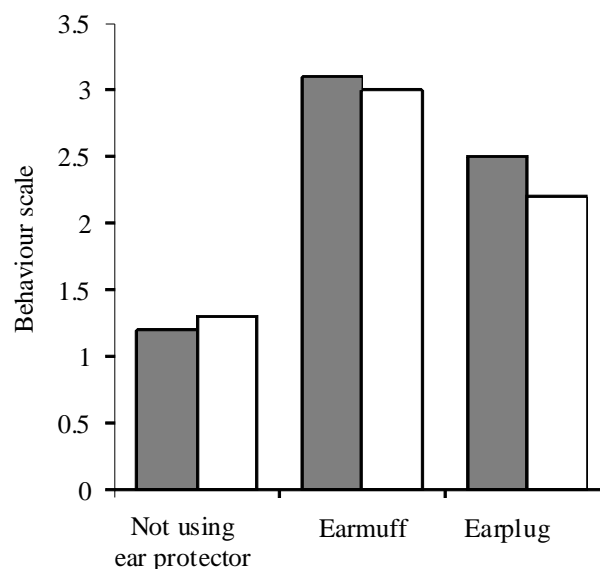


Figure 6 Perception of chainsaw operator versus non operator on receiving noise during racing condition. Operator (■), non operator (□).



This condition could be described in the study by Yovi (2009) and Yovi *et al.* (2011) as a lack of attitude which was the main issue in work competency of logging workers. In this study, it was found that the majority of workers knew the potential health and safety risks when working without protective equipments, they were also skilled enough to pick and wear personal protective equipments appropriate to the needs of work, but they were reluctant to wear personal protective equipments as required. Further analysis of work concentration ability provided strong indication that basically almost all chainsaw operators have experienced decreased hearing abilities.

Perceptual differences were also found in treatments using earmuff and earplugs. Differences in perceptions at the time of using earplugs and earmuffs were due to the stronger reduction ability of earmuffs compared to earplugs. Earmuffs were able to reduce noise pressure to about 25–40 dBA, while earplugs could only reduce the noise pressure to about 80–30 dBA, depending on whether or not the earplugs were loosely inserted. The advantage of using earmuff was that it could be used in the presence of ear infection and available in one size only, not easily lost, and its use could be monitored as it could be seen from the outside. However, the disadvantage was that earmuffs were uncomfortable to be use under hot environments and interfered with the use of other protective equipments like goggles and helmets. While the advantage of using earplug was that procurement costs were much cheaper than earmuffs. Earplug could be made from cotton, candle, plastics, and synthetic rubber. The disadvantage of earplug, however, was the lack of protection of noises above 100 dBA, could not be used with ear infection, difficult to monitor because it is not visible, easily lost due to its small size, and need maintenance to keep it clean.

In terms of chainsaw operators' convenience of using earmuffs and earplugs, the majority of respondents argued that earmuffs were more convenient to use than earplugs due to its ability to reduce high-intensity sound. Nevertheless, the chainsaw operators stated that one disadvantage of using earmuff was that they could not hear the surrounding environment such as when warning is given during the felling of trees. Fears over threat to personal safety is still being felt despite the warnings using a whistle and the cue in the form of hand signals from the field supervisor. Fear of falling trees was also evident because within a cutting plot, there were 3–4 operators without good division of work location.

If the main reason for the reluctance to use earmuff was because of fear in inability to hear surrounding environment, this problem could actually be overcome by setting good job organization on each plot. Other alternative solutions include combination of the use of a whistle, megaphone or a means of distance communication, coordination between co-supervisor and assistant supervisor, or supervisor-operator assistant, and arrangements of felling sites between chainsaw operators. Notification of chainsaw operator to supervisor

assistant or operator assistant when he was ready to prepare undercut and back cut, could be passed on by the assistant to the other operator assistants (who then convey a very good communication with the operator) could increase the alertness of a chainsaw operator near location of trees to be felled. Therefore, it is clear that working arrangements supported by appropriate communication system would largely determined the success of the workers' safety protection within felling areas.

### **Respondent's concentration ability towards chainsaw noise**

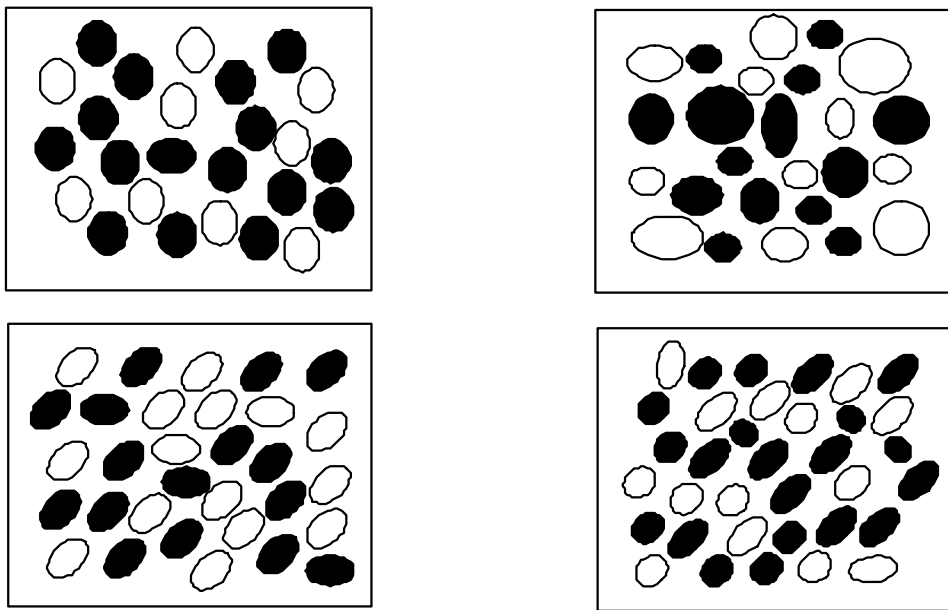
Based on the Great Indonesian Dictionary, concentration ability is defined as the concentration or focusing the mind on something. Concentration ability might be interrupted by a variety of reasons, among which were noise or other psychological problems such as personal problem or annoyance. Isolating psychological disorders of the workers are very difficult, therefore, this concentration ability was conducted by ignoring the psychological problems that might exist within the respondents. Thus, the respondents were assumed to not having any psychological problems at the time of the measurements.

The test was carried out by giving the workers a 25 simple math problems after being exposed to noise. Questions (Figure 7) used in the tests is easy, although it has undergone some modification in such a way. Easy questions were selected on the grounds that most of the chainsaw operators had low formal education, thus providing questions that were commonly used in psychological test could precisely refract the results of the tests. To obtain an appropriate level of difficulty, repetitions on preliminary test were conducted.

Data analysis using Wilcoxon test showed that the sound of chainsaws in iddle condition with an average intensity of 78 dBA showed no significant effect on the concentration ability of the operators (value Asymp. Sig .067). This condition was normal because the produced sound intensity at iddle only ranged around 80 dBA.

Surprising finding was shown for data analysis treated with racing condition without and wearing ear protective devices. Wilcoxon test showed that noise with an intensity of 100–104 dBA did not cause a decline in the concentration ability of chainsaw operators. This indicated that chainsaw operators were not disturbed by the sound intensity of chainsaw or has been normally exposed to the noise. Interviews and direct observation results showed that 80% of chainsaw operators in this study tent to always listen to music or watching television with a high volume. These findings indicated that although the operators admitted that they did not experience hearing loss but the fact is, chainsaw operator could not hear well without high-intensity sound. This is actually a strong indication of the noise-induced hearing loss or increased hearing thresholds of the operators due to noise exposure above 85 dBA (Gierke & Johnson 1978) and duration of exposure that exceeded the limit (Boateng & Amedofu 2004).

As with non-operators, the results of analysis using the



Please do the following: subtract the number of black dots from white dots.

Figure 7 Example of a simple mathematic used to test work concentration of workers after exposure to noise.

same test showed significant difference (Sig Asymp.  $< \alpha$ ; 0.05). This was especially seen under the combination treatment of iddle and racing conditions both without and wearing protective devices. Thus it can be said that noise generated by chainsaws disrupted concentration of non-operators because they did not want to be exposed to such level of noise intensity. Result of this study where there is a declining concentration ability of non-operators emphasis the findings of previous studies (Stansfeld & Matheson 2003) which proved that noise would affect workers performance (reduced concentration ability) in addition to altering social behaviour.

Hearing impaired caused by noise exposure is expected to not only experienced by the logging workers, but also by other forestry workers who had direct contacts with machines such as sawmills workers (Boateng & Amedofu 2004), especially if the ear protection devices were not used when performing work activities. It is recommended that the company should regularly conduct hearing check for chainsaw operators to avoid permanent reduction in hearing ability.

In terms of noise generated by chainsaws, noise is not the only source of danger for logging workers, but also the mechanical vibrations of the chainsaw (Takahashi *et al.* 1987; Morata 1993). A chainsaw operator would be exposed to both mechanical vibrations and noise while performing work. In this case, noise was thought to be the factor that accelerates vasoconstriction produced by mechanical vibrations because noise was thought to activate the sympathetic nervous system (Pyykkö *et al.* 1981). Noise effects for chainsaw operator could be worsened since almost all of the respondents were smokers whose effects exacerbated damage to hearing (Mizoue *et al.* 2003).

Analysis of the assessment of perception and concentra-

tion ability of workers performed on the two groups of respondents in this study proved that there was an increase of hearing threshold value of the chainsaw operators. These findings could form the basis of better forest management by providing more attention to safety and health of workers. Formulated field strategy should be cheap and easy to apply by following the principles of anthropocentric ergonomics which is an amalgamation between research, education, technology, and policy (Thelin 1990; Concha-Barrientos *et al.* 2004; Yovi 2009; Yovi *et al.* 2011).

## Conclusion

The perceived sound intensity of the chainsaw received by chainsaw operators and non-operator were significantly different. Nonetheless, the perceptions of both groups of respondents on noise showed similar tendency that is increased disturbances with increasing sound intensity. Data analysis shows that the concentration ability of chainsaw operators when exposed to high-intensity sound is not disturbed, as opposed to the non-operators exposed to the same level of intensity. Factors that are believed to affect this are, the declining hearing ability due to prolonged interaction with the chainsaw sound that exceeds the threshold intensity and threshold for duration of exposure without the use of appropriate ear protection devices. This indicates the immediate need for appropriate modification of work management.

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